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Potential Benefits of Increased Access to Space for Secondary Payloads

Brian J. Horais
Mark Goergen

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Overview

- Why increase the availability of secondary payload access to space?
  - To Increase the frequency of component testing in space
    - TRL-7* requires prototype demonstration in the space environment
    - This often imposes a “brick wall” for new space component development
- What components and payload sizes lend themselves to secondary payloads?
  - Processors, instruments, sensors (not tied to aperture requirements), and enabling devices for new concepts
  - Small and simple secondary payloads in the tens of kg size or less
  - Simple, dedicated space experiments that qualify specific components
- Does the US rate of secondary payload launches need to be increased?
  - Yes, if it can support more rapid development and qualification of new space components and technologies
    - At a cost affordable to organizations developing innovative space components

*TRL - Technology Readiness Level

Technology Readiness Levels

- Technology Readiness Levels (TRLs) are a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology.
  - [John C. Mankins, Advanced Concepts Office, Office of Space Access and Technology, NASA White Paper, April 1995]
- New Space Component Development often encounters a "Brick Wall" between TRL 6 & TRL 7 due to the limited number of space test opportunities

TRL 1 Basic principles observed and reported

TRL 2 Technology concept and/or application formulated

TRL 3 Analytical and experimental critical function and/or characteristic proof-of concept

TRL 4 Component and/or breadboard validation in laboratory environment

TRL 5 Component and/or breadboard validation in relevant environment

TRL 7 System prototype demonstration **in a space environment**

TRL 8 Actual system completed and "flight qualified" through test and demonstration (ground or space)

TRL 9 Actual system "flight proven" through successful mission operations

Why is Space R&D Difficult?

Applying the Scientific Method for Space Component Development imposes severe environmental and cost constraints not present in ground-based R&D

Elements of the Scientific Method	R&D on the Earth	R&D in Space
1. Observe	Straightforward in situ	Difficult in situ – often done remotely
2. Develop Hypothesis	Develop based on many observations	Developed based on limited observations
3. Test Hypothesis	Straightforward and "hands-on"	Very difficult, costly, and done remotely
4. Iterate 2 & 3	Iteration cycle in days to weeks	***Iteration cycle in years***

The rate of development for new TRL-7 level space components is hampered by the slow space test iteration cycle

Applying the Scientific Method

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The Scientific method of;

- *Observation*
- *hypothesis, and*
- *testing*

offers an approach to address the question of:

"What benefits could result from an increased rate of secondary payload launches?"

Observation	Since the 1990s The International Space R&D community has conducted a significantly higher rate of secondary space payload launches that the U.S.
Hypothesis	Increased frequency of testing shortens the development iteration cycle for space components and leads to more rapid introduction of new component technologies
	a)Establish more frequent secondary payload launch opportunities in the US by developing the infrastructure to utilize excess payload margin on U.S. launch

Scientific Method: Applied

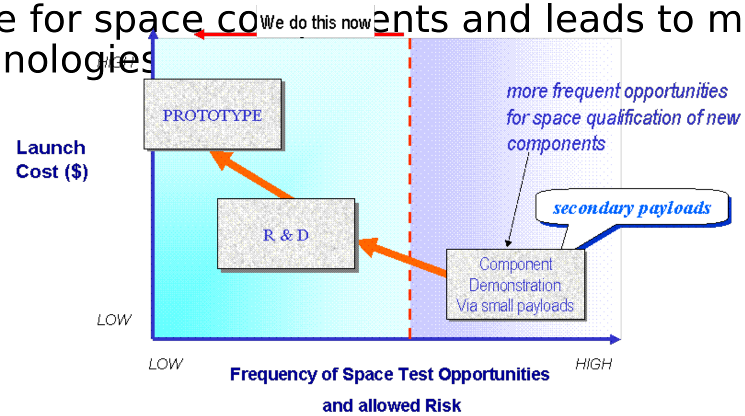
Observation: Since the 1990s The International Space R&D community has conducted significantly more secondary space payload launches that the U.S.

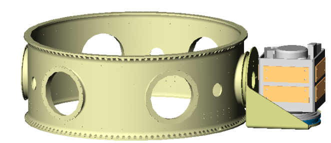
BASIS FOR OBSERVATION:

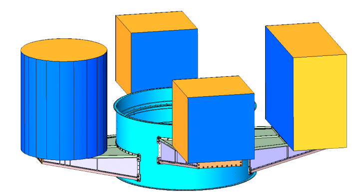
– 1) Comparison of US Space Test Program (STP) and Ariane ASAP (Auxiliary Structure for Secondary Payloads) launch rates over the period 1990-2000

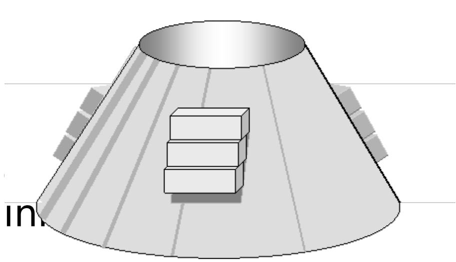
– 2) Comparison of US Delta II versus Ariane IV ASAP Secondary Payload launches, 1990-2000

Hypothesis: Increased frequency of testing shortens the development iteration cycle for space co[mpon]ents and leads to more rapid introduction of new technologies









Testing:

a) Establish more frequent secondary payload launch opportunities in the US by developing the infrastructure to utilize excess payload margin on U.S. launch vehicles

b) Over a 5 year period, Evaluate the impact of these ad launch opportunities on US space in

Observation: Secondary Payload Launch Rates

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From 1990 thru 2000 the International Space R&D Community outperformed the U.S. Space R&D Community in their rate of small payload l

The U.S. Space Test Program manages the launch of most of the Defense related R&D payloads

Ariane's Structure for Auxiliary Payloads was developed as a commercial capability

- **Missions to Date (thru '02)**
- **Rate of 1 per year**
- **Custom Interface**
- **Ad-hoc launch opportunities**
- **Cost subsidized by DoD**
- **Strong success story in DoD spacecraft heritage**
  - Milstar
  - DSCS
  - GPS
  - DMSP
  - DSP

- **Launched 26 Free-Flyer Missions to Date (thru '00)**
- **Rate of 2.36 per year**
- **Standard Interface**
- **Scheduled launch opportunities**
- **Costs within reach of small research organizations**
- **ASAP has "bootstrapped" several small countries into the space business**
  - South Korea
  - Portugal
  - South Africa

SOURCE: COL White, USAF, STP Program Overview Briefing, August 2002

SOURCE: Surrey Satellite Technology Database for Smallsat Launches, http://centaur.sstl.co.uk/SSHP/micro

Observation: Quantity versus Quality

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- Launch Rate alone is not a true indicator of space R&D Progress, but it can enable a more rapid space development/qualification cycle for new space components
- A comparison of Delta II and Ariane IV secondary payload launches during the period 1990 thru 2000 provides a basis for payload and launch rate comparison

Delta II Secondary Payloads

SECONDARY PAYLOAD	LAUNCH DATE	LAUNCH SITE	PRIMARY PAYLOAD
LOSAT-X	July 3, 1991	CCAFS	Navstar II-11
DUVE	July 24, 1992	CCAFS	Geotail
SEDS-1	March 29, 1993	CCAFS	GPS-1
PMG	June 26, 1993	CCAFS	GPS-3
SEDS-2	March 9, 1994	CCAFS	GPS-6
SURFSAT	November 4, 1995	VAFB	Radarsat
SEDSAT	October 24, 1998	CCAFS	Deep Space 1
Ørsted, SUNSAT	February 23, 1999	VAFB	P91-1 ARGOS
Munin	November 21, 2000	VAFB	EO-1/SAC-C

Delta II Launch Record for Secondary Payloads[7]

Delta II secondary payloads were primarily scientific experiments with some tether experiments

SOURCE: Karuntzos, Keith W., Delta II Launch Opportunities, 2001 Small Payload Rideshare Conference

Ariane IV Secondary Payloads

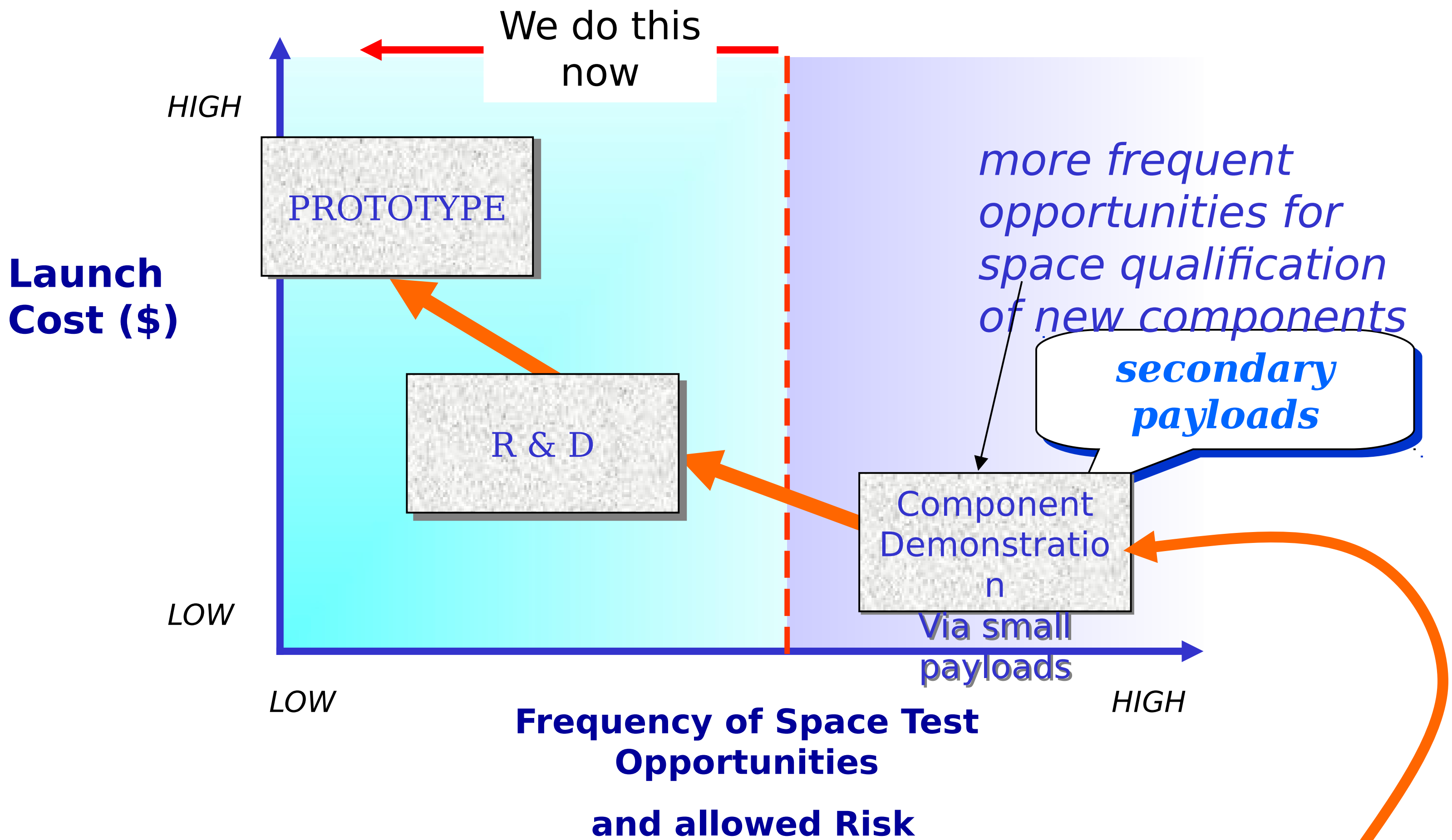
Launcher	Date	Primary	ASAP (Secondary) payloads
Ariane IV V35	21 JAN 90	SPOT-2 (CNES - FR)	UOSAT-3 & 4 (U. of Surrey - UK) AO16,17,18 &19 (AMSAT N.A - USA)
Ariane IV V44	17 JUL 91	ERS-1 (ESA)	UOSAT-5 (SSTL - UK), SARA (FR) ORBCOMM-X (USA), TUBSAT (GER)
Ariane IV V52	10 AUG 92	SPOT-2 (CNES - FR)	S 80/T (SSTL - UK), KITSAT-1 (SSTL for SaTReC - S. Korea)
Ariane IV V59	25 SEP 93	SPOT-3 (CNES - FR)	STELLA (FR), KITSAT-2 (SSTL/S. Korea) PoSAT-1 (SSTL/Portugal), Eyesat (USA) ITAMSAT (AMSAT-Italy) Healthsat-2 (SSTL UK/USA)
Ariane IV V64	17 JUN 94	INTELSAT 7	STRV 1a & 1b (DRA/BMDO - UK/USA)
Ariane IV V75	7 JUL 95	Helios-1	CERISE (SSTL for DG - France) UPM-Sat (U of Madrid - Spain)
Ariane IV V124	3 DEC 99	Helios-1b	Clementine (SSTL for DGA - FR)
Ariane V V132	15 NOV 00	PanAm Sat's PAS-1R	STRV 1c & 1d (DRA - UK), AMSAT Phase 3-D

SSTL - is Surrey Satellite Technology Limited, a commercial affiliate of the University of Surrey, UK

Ariane IV secondary payloads were primarily communications and small imaging experiments and some DERA/UK payloads

SOURCE: Surrey Satellite Technology Database for Smallsat Launches, http://centaur.sstl.co.uk/SSHP/micro

Hypothesis: Increased Testing Rate



Increased availability of secondary payload launch opportunities in the U.S. could facilitate more rapid space component qualification

Testing: Developing the opportunities

- Developing the infrastructure and components in parallel may provide a basis for testing the hypothesis:

  “Increased frequency of testing shortens the development iteration cycle for space components and leads to more rapid introduction of new space component technologies”

- These Initiatives are only part of the solution:
  - Government Space R&D / Launch Vehicle Industry collaboration will be required

Conclusions

- An approach has been presented to use the scientific method to address the question:

  "What are the Potential Benefits of Increased Access to Space for Secondary Payloads?"

- To address this question there is a need to:
  - Identify relevant components for small space payload testing
  - Develop the infrastructure to support additional secondary launch opportunities for these component test payloads

Backup Charts

Ariane ASAP Launches

Launcher	Date	Primary	ASAP (secondary) payloads
Ariane IV V35	21 JAN 90	SPOT-2 (CNES - FR)	UOSAT-3 & 4 (U. of Surrey - UK) AO16,17,18 &19 (AMSAT N.A - USA)
Ariane IV V44	17 JUL 91	ERS-1 (ESA)	UOSAT-5 (SSTL - UK), SARA (FR) ORBCOMM-X (USA), TUBSAT (GER)
Ariane IV V52	10 AUG 92	SPOT-2 (CNES - FR)	S 80/T (SSTL - UK), KITSAT-1 (SSTL for SaTReC - S. Korea)
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Delta II and Ariane IV Secondary Payloads

DELTA II Secondary Payloads: 1991-2000

- LOSAT Ball, MSI Imaging
- DUVE NASA UV measurements
- SEDS-1 NASA tether experiment
- PMG Tether experiment
- SEDS-2 Tether experiment
- SURFSAT JPL DSN Comm experiment
- SEDSAT UAH Education, remote sensing
- SUNSAT Stellenbosch Univ., Remote

The Ariane IV ASAP (auxiliary structure for secondary payloads) enabled a higher secondary payload launch rate than Delta-II over the 10 year period 1990-2000 and lead to the introduction of new space programs in a number of non-US countries

Ariane IV Secondary Payloads: 1991-2000

- UOSAT-3 & 4 COMMS, store and forward
- AO 16, 17, 18 & 19 AMSAT COMMS
- UOSAT -5 COMMS, store and forward
- SARA France, Stellar Emissions
- ORBCOMM-X OSC COMMS, GPS
- TUBSAT Antarctic COMMS, tracking
- S 80/T CNES, VHF characterization
- KITSAT-1 Korea, COMMS and Imaging
- STELLA France, passive reflector
- KITSAT-2 Korea, COMMS and Imaging
- PoSAT-1 Portuguese COMMS & Imaging
- EyeSat US, store and forward COMMS
- ITAMSAT Italy, store and forward COMMS
- HealthSat-2 Emergency COMMS
- STRV 1a & 1b DERA, space environment testing
- CERISE France, ELINT
- UPM-Sat Spain, Remote Sensing
- Clementine France, eavesdropping
- STRV 1c & 1d DERA Space Experiments
- AMSAT Phase 3-D AMSAT GEO COMMS

SOURCES: SSHP Small Satellites Website, Historical Launch Data http://centaur.sstl.co.uk/SSHP/micro and various web searches

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Delta II Secondaries

Delta II has been the workhorse of secondary payload launches in the US

SECONDARY PAYLOAD	LAUNCH DATE	LAUNCH SITE	PRIMARY PAYLOAD
LOSAT-X	July 3, 1991	CCAFS	Navstar II-11
DUVE	July 24, 1992	CCAFS	Geotail
SEDS-1	March 29, 1993	CCAFS	GPS-1
PMG	June 26, 1993	CCAFS	GPS-3
SEDS-2	March 9, 1994	CCAFS	GPS-6
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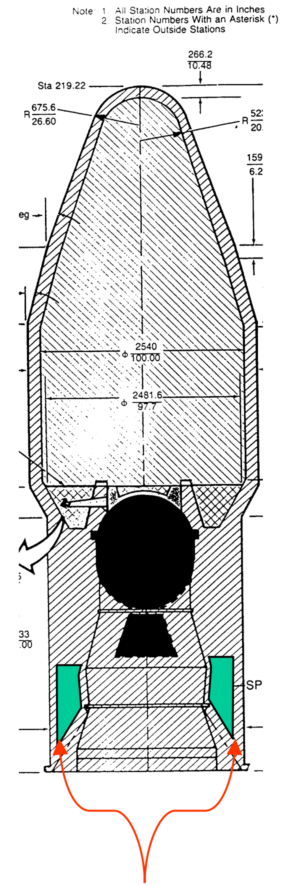

Secondary Payload Volumes on Delta II